DEVELOPMENT OF LOW WEIGHT MAGNESIUM COMPOSITE AND ITS CHARACTERISATION

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Abstract - *The following paper presents the study of mechanical behavior of Mg alloy (AZ91D) and its composites. Mg alloy is processed by stir casting method in order to make its composite by using SiC as reinforcement. The stir casting method involves melting of Mg which works as metal matrix and then silicon carbide is poured into it. Different specimens were prepared by varying the percent composition of Silicon carbide. Several tests were performed in order to analyze the mechanical behavior. By Tensile test, we came to know that yield stress, ultimate tensile strength, and toughness of the material enhanced. Under the optical microscope, we observe on increasing the reinforcement composition grain size reduced and also as the size of reinforcement reduced resulted in the reduction of grain size. XRD Test is performed to analyze crystal spacing, grain size, crystal orientation and crystal structure*

Key Words: **Mg alloy (AZ91D), Composites, SiC, Metal matrix, Reinforcement, Stir casting, tensile test, Optical microscope, XRD Test**

1. INTRODUCTION

The development of lightweight and energy efficient material has been always an attraction of all the industries in the 21st century. Magnesium due to its light weight and high strength to weight ratio has a big potential to replace other material in the industry [2]. Earlier the cost of extraction of mg was high but now a day's cost of extraction reduced due to technological advancement. This brings a new material as a lightweight material. Mg alloy has greater solidification characteristics over other material like copper and aluminium. Magnesium is the lightest of all light metal alloys and therefore is an excellent choice for engineering applications when weight is a critical design element. It is strong, has good heat dissipation, good damping and is readily available. Its properties make it easy to weld, forge, cast or machine. The major technique to make mg composite is stir casting, sintering, die casting, centrifugal casting and pressure die casting .we have chosen stir casting method as it is a cheap, fast and accurate method for mass production. Magnesium does not react with iron but problem associated is with the presence of aluminium in the mg alloy. Aluminium readily reacts with iron present in the crucible. So to avoid this problem crucible is coated with boron nitride.

2. STIR CASTING PROCESS

It is one of the most economical and effective method for casting of composites. In stir casting process we use to melt the metal matrix in the vacuumed furnace and after that reinforcement in powdered form is poured into the furnace. After pouring of reinforcements into the metal matrix, the whole mixture was stirred for proper distribution of reinforcements in the metal matrix.

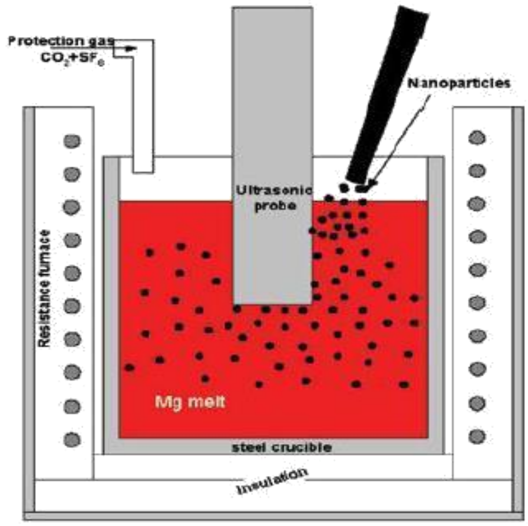

Figure 1- Mixing of reinforcement in molten metal alloy [1]

stirring is required because due to density difference between metal matrix and reinforcements they get separated leading to improper distribution of reinforcements which results in several defect.

In older stir casting machine we have to do the stirring process manually by the help of stirrer. But the machine available at KNIT SULTANPUR have advanced stir casting machine equipped with an automated stirrer, which results in proper distribution of reinforcements in the metal matrix. In order to provide vertical movement to stirred rod, and another stirrer motor is used to hold stirrer rod. This stirrer motor has vertical movement from 1 mm to 60 mm.

Figure 2- Stir casting machine at KNIT Sultanpur.

The molten metal mixed with reinforcement in molten state is poured into the die which is kept inside die chamber .And die chamber is also kept vacuumed. In order to avoid porosity and other defects if air/ gases remain inside the chamber. We have produced 4 composite sample with varying SiC % i.e. 3%, 6%, 9% and 12%. During the process of casting, we get to know that better distribution of reinforcement will occur when the reinforcement is poured into the furnace when the magnesium alloy is in its semi-molten state. And after that metal reinforcement mixture should be heated up to the melting temperature of the metal. This will ensure proper distribution of reinforcement in the metal matrix.

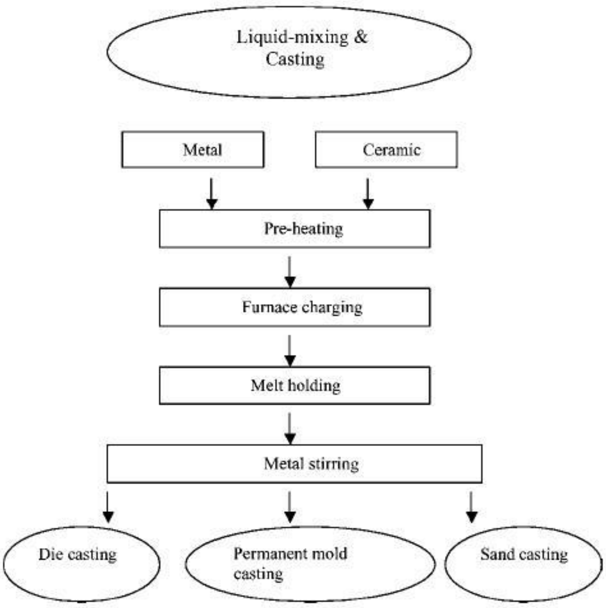

Figure 3- Process of stir casting.

3. TESTING AND ANALYSIS

3.1 Tensile testing

Tensile testing is performed by taking the specimen of 2 mm thickness; 20 mm gauge length and 70 mm total length. The specimen should be free from any kind of notches and rough surface in order to avoid stress concentration.

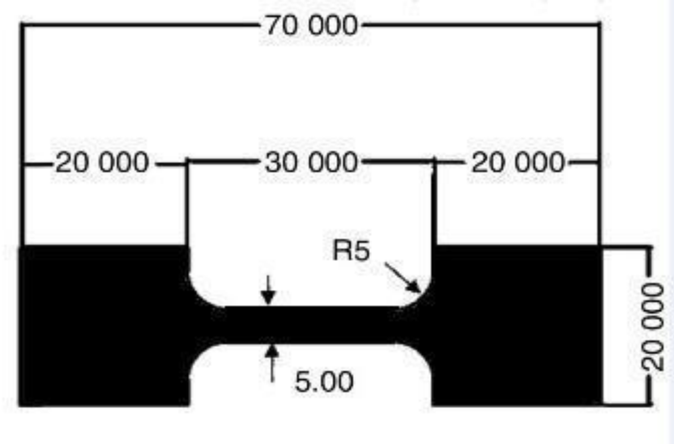

Figure 4- Tensile test specimen (all dimension in mm)

Each sample including base metal is tested on UTM (universal testing machine). So obtained table for different composition is shown in below table.

S.no.	%	Ultimate tensile Strength (MPa)	Yield load (KN)	Peak load (KN)
1.	AZ91D (0% SiC)	112.756	0.812	1.489
2.	3% SiC	136.3554	1.387	1.714
3.	6% SiC	139.527	1.21	2.122
4.	9% SiC	187.607	1.919	2.438
5.	12% SiC	193.956	1.264	2.478

Table 1-Test results of tensile testing for different specimen.

On increasing the percentage composition of the SiC there will be an increase in ultimate tensile strength, yield stress and peak load. Area obtained from load v/s displacement graph of different composition depicts toughness also get increased.

3.2 Microstructure

The Microstructure of magnesium alloy and 3% SiC is observed under optical microscope. Optical microscope is used to observe grain boundaries and grain size variation with change in the composition of SiC.

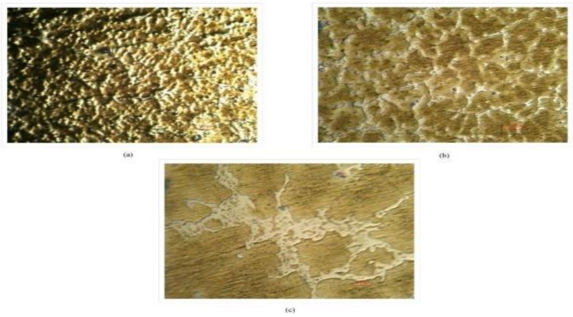

Figure 4 - Image of AZ91D under optical microscope.

The above obtained microstructure is of Mg alloy (AZ91D). We can observe as the material is free from reinforcements therefore there is no black spots and grain boundaries are clearly visible under 400 X magnification.

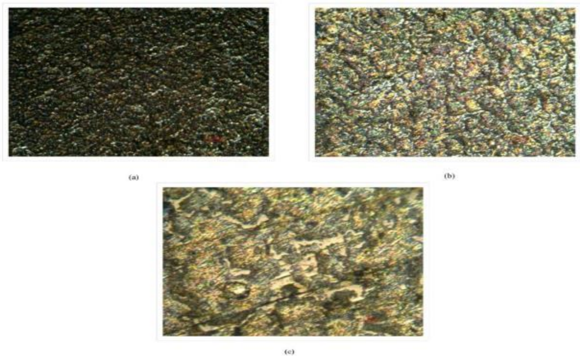

Figure 5-Image of composite (3% SiC) under optical microscope

Above fig. is of 3% SiC-Mg composite in which black spots shows the presence of SiC. Grain size becomes smaller in size not clearly visible even under 400 X magnification. By observing all the microstructures for different composition we can conclude that grain size decreases with the presence of % SiC present and the grain size further decreases as the reinforcements size decreases. And even grain boundaries thickness becomes finer under same magnification.

3.3 XRD Test

XRD Test is performed to identify crystal structure, inter planer spacing, grain size and orientation of the crystal, state of stress present in metal. The base metal sample and 3 % SiC composition is tested under XRD machine at Jawaharlal Nehru University advanced instrumentation and research facility (JNU AIRF). We get following graphs.

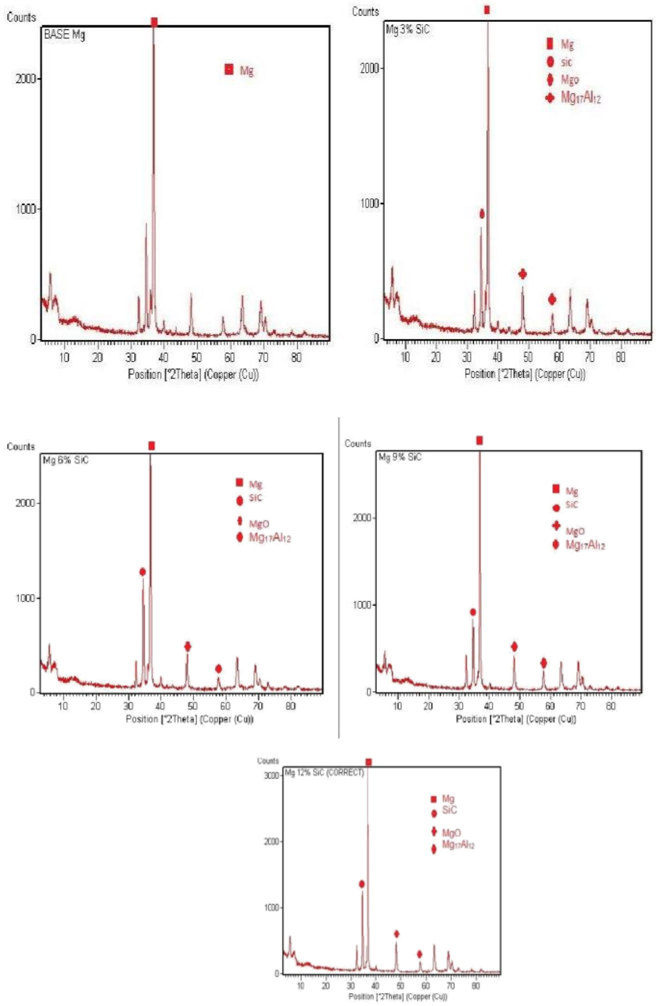

Figure 6- XRD of (a) AZ91D (0% SiC) (b) 3% SiC (C) 6%SiC (d) 9% SiC (e) 12% SiC

From the following graphs we can conclude that the composite has its crystallinity of Mg at 30˚ - 40˚ (2 theta angle), and as graph is not deflected towards right or left means material was free from stress concentration. The peak with highest counts represent base metal, and second highest represent SiC lowest intensities show amorphous materials present in the composites.

By comparing with Jcpds data it is found that there is a peak of magnesium, silicon carbide, MgO, Mg17Al12 but there is no peak of Al4C3 and Mg2Si which shows that they are present in there brittle and unstable form [3] and their phases are suppressed. Therefore, the present mixing and casting technique is fit for making of composites.

3. CONCLUSIONS

The casted product from stir casting set-up was defect and porosity free as well as the distribution of alloying element and the reinforced particle was also uniform. The machining of Mg alloy is very easy and provides the good surface finish after machining, but the machining of particulate reinforced Mg alloy is slightly brittle and produces short length chips. On increasing the SiC % the grain boundaries began smaller in size, grain boundaries also become smaller in size if the size of SiC particles is made small. The tensile test is performed showed that on increasing SiC content the ultimate tensile strength, peak load and yield strength increases. The toughness of the material is decreasing .which can be seen from load v/s displacement curve area Toughness of the material was increasing due to increasing brittleness as SiC reinforcements are added into it. During stir casting process addition of reinforcements SiC in semi-molten state and again heating up to the melting temperature. Results in proper distribution of reinforcements which results in the better analysis of material, proper machining, and good standard results for, tensile testing, better microstructure, and proper XRD results.

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REFERENCES

[1] Anil Kumar, Santosh Kumar, N K Mukhopadhyay "Study of Magnesium processing technology and development of low-cost stir casting process for Mg-Alloy and its composites."

[2]Bowen Xiong, Huan Yu, Zhifeng Xu, Qingsong Yan, Changchun Cai,"Fabrication of SiC particulate reinforced AZ91D composite by vacuum-assisted pressure infiltration technology"

[3] Jayaraman Jayakumar, B.K.Raghunath, T.H.Rao. "Recent Development and Challenges in Synthesis of Magnesium Matrix Nano-Composites"